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PLOTTING OF THE SEA SURFACE PATTERN IN THE STRAIT OF GIBRALTAR --ETC(U)

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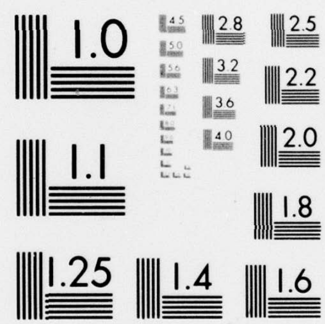
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LEVEL II

PLOTTING OF THE SEA SURFACE PATTERN IN THE STRAIT OF GIBRALTAR FROM OBLIQUE AERIAL PHOTOS

C-2

by

William Osborn

Columbia University
Hudson Laboratories
Dobbs Ferry, N. Y.

TM-48

Contract N6-ONR-27135

COLUMBIA UNIVERSITY
HUDSON LABORATORIES
CONTRACT Nonr-266(84)

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(6) PLOTTING OF THE SEA SURFACE PATTERN IN THE STRAIT OF GIBRALTAR FROM OBLIQUE AERIAL PHOTOS.*

(12) 13 p.

by

(10) William Osborn

Columbia University, Hudson Laboratories
Dobbs Ferry, New York

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ABSTRACT

Part of the data gathered in connection with research being done by Mr. Roberto Frassetto is a series of oblique aerial photos of the sea. For his purpose, their interest lies in certain surface patterns that can be seen.

In order to study these in connection with other known data, it was necessary to plot these patterns on a map of the area, preliminary to attempting to assay the correlations that may exist.

At ~~his~~ Mr Frassetto's request, ~~I have~~ the Author has written the following description of the process by which this was done, shown its trigonometric basis, and made new drawings by way of illustration. ABSTRACT

William Osborn

PLOTTING OF THE SEA SURFACE PATTERN IN THE STRAIT OF GIBRALTAR FROM OBLIQUE AERIAL PHOTOS

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These photos, 9 in. by 9 in., taken in 56 runs in July 1959 by a K-17 camera, were from heights of 5000 ft, 7000 ft, and 10,000 ft, mostly at 5000 ft. Four runs were taken at 1300 ft. All runs were across the Strait, the camera looking roughly east or west.

In the majority of runs the horizon was above the top of the photograph, its approximate position being determined by reference to marks on the rear of the plane wing, which always shows in the upper right corner of the photos.[1] In this manner, the approximate depression angle of the camera in-

(1) This is subject to error due to pitch and roll of the plane. Ideally, the horizon should show at the top of the photo.

cluding dip, was found to vary from 43° 42' to 22° 24'. For the smallest depression angle (22° 24'), used in the runs made at 1300 ft, the horizon was well within the photo. Some of the photos from runs at 5000 ft had a true depression angle of 31° 16' and showed the horizon near the top.

In order to plot the sea surface pattern shown in the photos transparent perspective grids, known as Canadian grids, were prepared for the several cases, following the trigonometric computations indicated in the revised Bowditch navigation manual[1] and in the Manual of Photogrammetry.[2] These are good for use on photos of flat country only. For this reason shore landmarks must be used as reference, not elevated ones.

The information necessary to proceed with this computation is:

1. The focal length of the camera lens (in this case 6 in).
2. The height of the airplane in feet.
3. The desired area unit to be shown on the grid. This will resolve into number of feet on the ground per inch on the front ground line of the photo plane.

The procedure is as follows:

(1) Bowditch, American Practical Navigator (U. S. Navy Hydrographic Office, Washington, D. C., 1958), chap. xliii.
(2) Manual of Photogrammetry (Am. Soc. Photogrammetry, Washington, D. C., 1952).

1. The apparent depression angle of the camera is computed. The tangent of this angle is the distance from the center of the photo to the visible horizon, divided by the focal length of the lens.

$$\frac{PH_1}{f} = \text{tan of apparent depression angle}$$

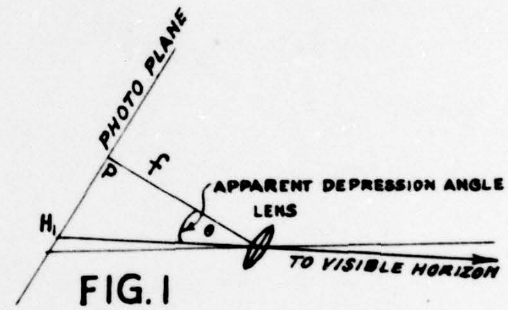

Fig. 1

2. The true depression angle θ (from the photo center to the true or bubble horizon) is obtained by adding to the apparent depression angle the angular quantity called DIP, which is a function of the height of the camera, refraction, and the curvature of the earth. This has been found to be accurately enough given by the expression $0.97\sqrt{H}$. H is written in feet, and D is supplied in minutes.

3. The true, celestial, or bubble horizon is next computed.

$$\frac{PH_2}{f} = \text{tan of true depression angle } \theta$$

H_2 is the central vanishing point for the grid

Fig. 2

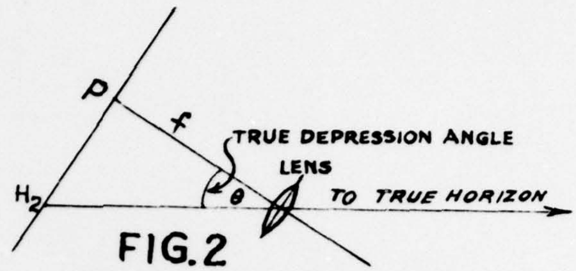

FIG. 2

4. To establish the scale of the grid, a distance H_2G in inches must be computed from H_2 to G, the center of the front ground line in the photo plane. This distance will vary with the choice of the number of feet per inch of grid on this front ground line. The grid has full scale on this forward horizontal line and proceeds into the picture to the vanishing point. G may occur in the photo if the horizon and height are low, but it is usually below the photo.

The grid ratio chosen was 607.6 ft/in (1/10 nautical mile/in). The grid squares inked in were 1/2 nautical mile on a side.

Fig. 3

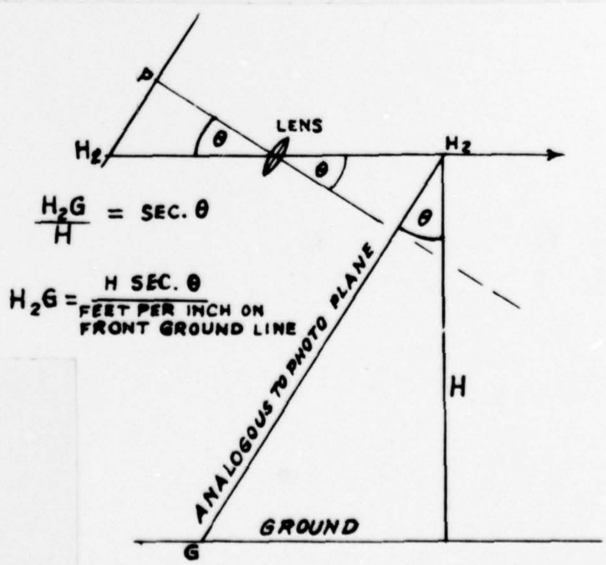

FIG. 3

5. The horizontal front ground line passing through G is drawn on the construction sheet, and inches are marked off on either side of G. At the desired interval, grid lines are drawn to the central vanishing point. These should be extended as far to each side of the construction as practical (see Fig. 5, on p. 9).

6. Grid diagonals are needed to establish the horizontal divisions of the grid. These diagonals are parallel lines on the ground, but converge on the grid at two vanishing points on either side of H_2, the central vanishing point. This distance $H_2 V_1 = H_2 V_2$ and its relation to θ and f are demonstrated in Fig. 4.

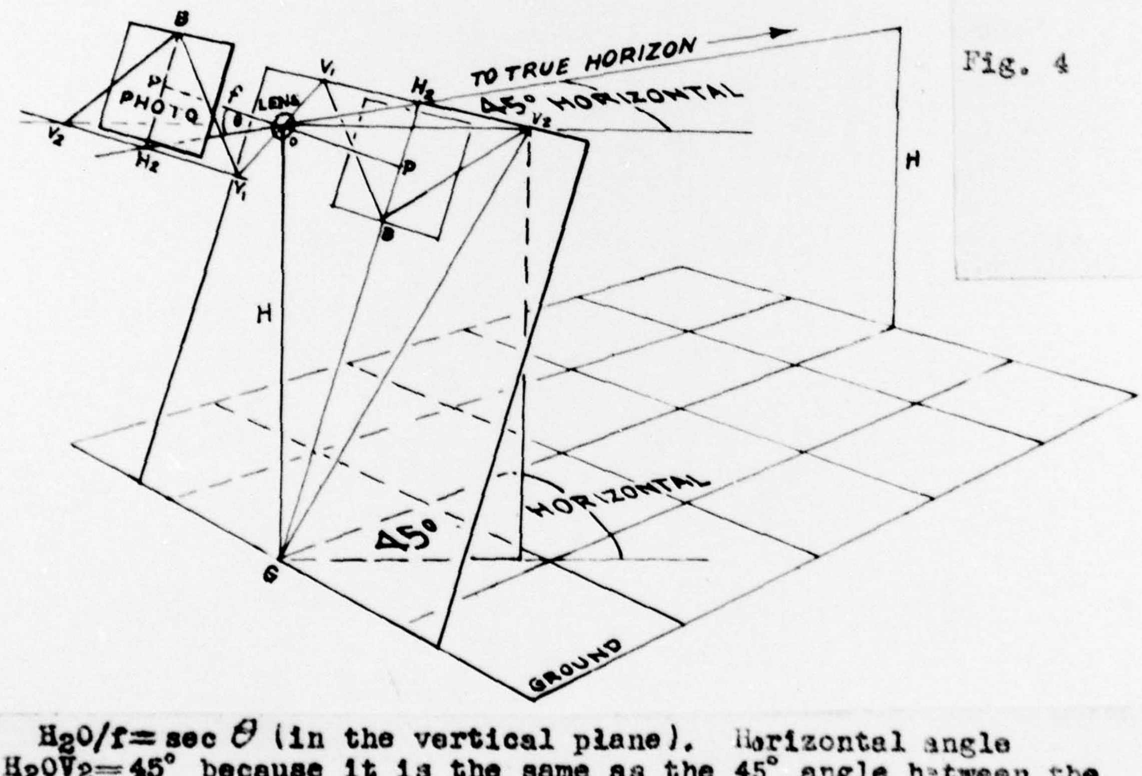

Fig. 4

$H_2O/f = \sec\theta$ (in the vertical plane). Horizontal angle $H_2OV_2 = 45°$ because it is the same as the 45° angle between the diagonal on the ground and the grid square that contains it. ∴ $OH_2 = H_2V_2$ because an isosceles right triangle has two sides equal. ∴ $H_2V_2/f = \sec\theta$ and $H_2V_2 = f \sec\theta$.

7. In order to have the grid squares start at the front of the photo, let the two initial diagonals BV_1 and BV_2 in the construction start at the bottom center of the photo, and proceed to V_1 and V_2. They intersect the grid lines converging at H_2. These intersections are grid corners establishing necessary horizontal lines.

From the centers of the horizontal lines thus obtained, more diagonals are drawn to V_1 and V_2, providing more intersections with centrally converging lines. Through these intersections more horizontal lines and more lines converging at H_2 can be drawn. This process is carried upward into the distance until the grid is reduced to a useful limit.

8. Numerical values are next labeled on the grid, and a tracing is inked on clear film. On this the diagonals are not needed. A second sheet of clear film is laid over the tracing and sealed by tape at the edges to exclude dirt and protect the ink.

Before using the photos, the center point of each is found by two intersecting pencil lines connecting the bisecting marks at the top, bottom, and sides of the photo. In all these flights, the camera's transverse vertical axis, as fastened, had an angle of inclination to the vertical, which

is drawn in pencil on the photo from the center point with reference to the vertical bisector.

A horizon segment, at right angles to this inclined vertical, is drawn on all photos depressed below the visible horizon. The horizon is drawn at the indicated height with reference to the plane wing marks, on the margin in the upper right corner or on a pasted tab of paper extending upward if the indicated height is above the photo.

It was found practical to have three cases of different vertical horizon distance from the photo center (or three depression angles) for the same height on the same film, using the same central vanishing point. One case was inked in black, one in red, and one in blue.

In use over a photo, the vertical center line of the grid is placed in register on the inclined vertical on the photo and the visible horizon line of both brought together. If the red center point is closest to the photo center point, the two latter are made to coincide, and the red grid and values are read.

Obviously if the depression angle is between the cases given, the values read are less accurate but are a useful approximation, the magnitude of the discrepancy being greater in the distance.

9. The photo runs studied, being across the Strait, had many photos in mid-run without landmarks. To

place the surface pattern of each run on the map, the flight path was located on a sheet of tracing paper over the map by means of identified coastal points at the beginning and end of the run. By dividing this path by the number of photos taken, the center line for each photo was established, since the photo interval was constant.

10. The desired detail was plotted on these flight path sheets and transferred to the map by means of a light table.

At this stage, the sea pattern, now in position geographically, can be studied with other known data to discover what correlation may exist.

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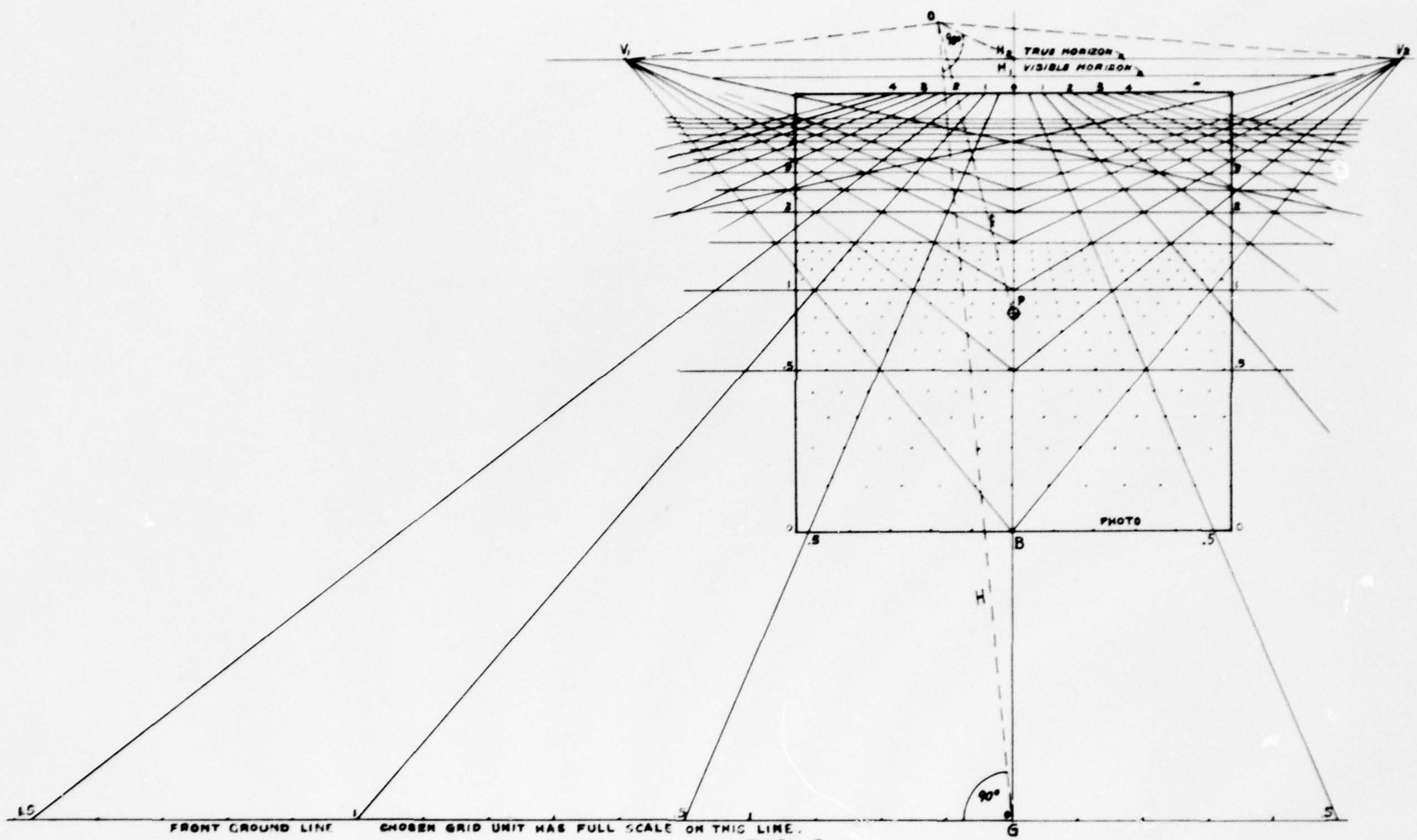
O
90°
V_1
V_2
H_2 TRUE HORIZON
H_1 VISIBLE HORIZON
4 3 2 1 0 1 2 3 4
P
PHOTO
B
H
90°
G
1.5
1
.5
.5
FRONT GROUND LINE
CHOSEN GRID UNIT HAS FULL SCALE ON THIS LINE.

FIG. 5

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Name FAGAN - OSBORN

Order 8" X 10"

Date 8/29/60

Remarks